3.2
ENERGY EFFICIENT HVAC

3.2.2
INTERNAL HVAC POLLUTION

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1 - LARGE BUILDINGS

1.1 OUTDOOR AIR INTAKES / EXHAUSTS

External sources of contaminants such as bioaerosols and combustion products often enter HVAC system outdoor air inlets. Contaminants in exhaust emissions often entrain in outdoor air inlets. HVAC then becomes **direct** source of air contaminants.

Remediation

- Outdoor air intakes should be located at a site (preferably on roof) where the ambient air quality is the best. This means that grade level sites should be avoided. Outdoor air inlets should be located at sites so that possible entrainment of contaminants from cooling towers, exhaust and relief vents, and other contaminant sources including those from other buildings is avoided;
- Fences should be used to separate outdoor air intakes from exhaust and relief air vents;
- Research is needed on airflow patterns around buildings in relation to optimal location or outdoor air inlets and exhausts;
- Keep outdoor air intake plenums clean;

1.2 ACCESSIBILITY OF INTERIORS OF CENTRAL AIR HANDLING UNITS (AHUS) FOR CLEANING

Accessibility to interiors of AHUs is often poor. Dirt, debris accumulate. Fleece factor becomes important. Result: HVAC-AHU becomes a direct source of air contaminants.

- Ceiling AHUs, rooftop AHUs, and central system AHUs must be designed for easy access for cleaning;
- Access panels should have smooth inner surfaces;

Research

- What is adequate access? Size of access panels? How many? Locations? How can penetration and leakage problems be minimized? Minimum guidelines of acceptability for manufacturers are needed.

1.3 MIXING PLENUMS OF AHUS

Assume AHU is accessible. Plenums (and rest of AHU) often are poorly maintained. Pesticides, VOCs, microbials often present in plenums. HVAC then becomes a direct source of air contaminants because of poor maintenance.

Remediation

- Keep mixing plenums clean;
- The use of odor maskers is unethical;
- The use of pesticides and the presence of open drains should be prohibited in mixing plenums.

Research

- Maintenance protocols are needed for rooftop units, central AHUs, AHUs in ceiling plenums;
- Quantify effects of maintenance deficiencies by panel of judges and by measurement of air contaminants;
- Develop maintenance rating checklists (scales) so that inspector can quickly rate this aspect of HVAC performance.

1.4 FILTER BANK OF AHU

Filter dirt likely acts as secondary emission source for ETS and VOCs. Moisture in filters means microbial amplification. All indoor air even in well maintained system passes through dust cake. This is probably not good for people.

Remediation

- Change filters frequently;
- Keep them dry.

Research

- Develop new technology so that filter dust cake in HVAC system air stream is avoided;
- Sensory perception. Can panel of judges "sense" dust cake?
- What is maximum air velocity in HVAC that is compatible with prevention of water droplet entrainment in air stream?
- Consensus protocols for filter maintenance for acceptable IAQ should be developed.

1.5 HEAT EXCHANGERS IN CENTRAL AHU

Contaminants arise in heat exchanger plenum because of stagnant water (biofilm) in drain pans, humidifiers and water spray systems and because of use of microbiocidal agents, etc. In some systems, cooling tower water (***Legionella***) is in cooling coil. HVAC system becomes a **direct** source of air contaminants.

Remediation

- Allow no stagnant water in HVAC; access to the drain pan for cleaning is essential;
- Coils with direct water connection to cooling towers must never leak (especially in hospitals);
- Biocides that can be aerosolized into indoor air should not be used in operating AHUs (drain pans), Water spray systems, and Humidifiers.

Research

- Detailed protocols for heat exchanger maintenance should be developed;
- Develop new types of humidifier that do **not** aerosolize microbiologicals, biocides, and corrosion inhibitors.

1.6 POROUS INSULATION IN HVAC

Porous insulation is found in AHUs (housing interior surfaces), supply air plenums, VAV boxes. Dirt and debris deposit over time in pores. Under high moisture conditions (for example downstream of operating cooling deck coils) fungi and bacteria will amplify of nutrients (dirt). Insulation also likely acts as secondary emission sources for VOCs and ETS.

Remediation

- Vacuum clean; replace insulation; externalize insulation; replace AHU; place insulation between metal surfaces.

Research

- What are acoustical penalties associated with externalization of insulation?
- Determine alternatives to cooling coil for latent heat removal; this might include desiccant dehumidification of incoming outdoor air;
- Determine if there are other approaches for dampening fan noise in HVAC.

1.7 COMMON RETURN AIR PLENUM

Common return air plenum can be source (direct and indirect) for entry of air contaminants into HVAC. Wet insulation and ceiling tiles are sources of microbials. Insulation can be secondary emission source of VOCs. Loose insulation can be source of irritating fibers in occupied space. Maintenance of AHUs in plenum is poor because of location (AHU then becomes source of air contaminants).

Recommendations

- Ducted returns should be used in place of common return plenums;
- Avoid the use of materials that can not be cleaned in common return air plenums; avoid the use of cellulose; avoid the use of high surface area materials.

Research

- Compare the economics of use of common return air plenum versus ducted return in view of IAQ, productivity, and overall construction costs;
- Carry out sensory panel tests to compare acceptability of ducted versus plenum return-air buildings;
- Research is needed on cleanable and non adsorbant/absorbant materials for use in common return plenums.

1.8 PERIPHERAL HVAC SYSTEM (INDUCTION UNITS; FAN COIL UNITS; UNIT VENTILATORS)

Peripheral units are associated with IAQ complaints (S. Burge). These units are excellent **direct** sources of microbials and secondary emissions of VOCs and ETS (especially hotels). Maintenance is almost always poor.

Recommendations

- Maintenance is required;
- Alternatively, these units should not be used in HVAC if maintenance is impossible.

Research

- Determine if these units be maintained in cost effective manner **or** should their use be discouraged (use central system AHUs instead);
- Quantify sensory and contaminants effects associated with the use of these units.

1.9 HVAC AS INDIRECT SOURCE OF AIR CONTAMINANTS

Providing outdoor air to breathing zone is an expensive and inefficient method for controlling some air contaminants such as VOCs, ETS, and human-shed microorganisms.

Recommendations

- Use source control.

Research (Human-shed microorganisms)

- Sick people (common cold) should stay away from work (source control). Health care plans should emphasize illness prevention. Study sick time loss in building with and without common-cold-management policies.

1.10 PRESSURIZATION OF BUILDINGS: EFFECT OF HVAC

Air contaminant from outdoor locations around a building can enter the indoor air because of improper pressurization. Air contaminants within a building can migrate from zone to zone because of pressure differentials. Thus, HVAC can become an **indirect** source of air contaminants.

Recommendations

- Total make-up air supply and total exhaust (relief) air output must be considered at **all** times in order to maintain proper pressurization;
- Strong external and internal contaminant sources must be excluded from the building or restricted by control at source in order to prevent building-wide dissemination.

1.11 CONCLUSIONS

HVAC systems can be major sources of indoor pollutants. Location of contaminants sources can be determined qualitatively by visual preassessment. Quantification of source strengths and health effects is difficult.

Remedial actions are often very obvious:

- Improvement in maintenance is most often associated with remedial actions;
- Some HVAC-sourced contamination sources however can be remediated only with great difficulty (for example, porous insulation; relocation of poorly located outdoor air inlets).

2 - RESIDENCES-MECHANICAL VENTILATION

2.1 MOISTURE - RESIDENCES

The presence of water in ventilation systems and in the occupied space can lead to significant indoor pollution (esp. microbial).

Recommandations

- Prevent accumulation of water/water vapour in ventilation systems;
- Prevent condensation of moisture on walls, windows, in the building envelope, parts of structure that communicate with the occupied space.

Research

- Better insulation systems (that avoid thermal bridging)for building envelopes are needed.

2.2 MAINTENANCE OF RESIDENTIAL VENTILATION SYSTEMS

All mechanical ventilation systems can become inefficient in terms of energy use if they are not properly maintained. Dirt and debris can accumulate in poorly maintained systems and can become primary and secondary sources of contaminant emissions.

Recommendations

- Keep ventilation systems clean by regular maintenance;
- The use of odor maskers is unwise and unethical.

Research

- Research on protocols for filter maintenance is needed;
- Develop audit procedures to access maintenance status.

2.3 MATERIAL SELECTION FOR VENTILATION SYSTEMS

Some materials used in ventilation systems can become primary (e.g., caulks, tapes) and secondary (porous insulation) sources of contaminant emissions.

Recommendations

- Internal surfaces in forced air systems should be smooth and should not be conducive substrate for mould growth;
- Locate fan motors outside of ventilation air stream;
- Use materials which have low source strenghts of potential contaminant emissions.

2.4 PRESSURIZATION

Some air contaminants enter residential indoor air because of improper pressurization differentials.

Recommendations

- Make-up air must be provided in such a manner that contaminants such as radon and combustion products (from the soil and garages, respectively), are not drawn into the occupied spaces;
- The movement of air contaminants from one dwelling (apartment) to another (through walls) must be prevented by proper zoning or by provision of separate ventilation systems.

REFERENCES

1. MOREY AND SHATTUCK. *Occup. Medicine: State of the Art Reviews*, 1989, vol. 4 (4), p. 625-642.

2. HODGSON AND MOREY. *Immunology and Allergy Clinics of North America*, 1989, vol. 9 (2), p. 399-412, (See especially table 4 on page 406).